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(54) Sound field and tone control device for FM radio receiver using radio data signals.

(57) In an FM radio receiver, in addition to automatic tuning to a station to be received. a sound field and tone control are performed in real time by utilizing RDS (radio data system) data multiplexed with a broadcast signal. An RDS signal detection section 14 detects RDS signal supplied from an FM detector 7 and the detected RDS signal is decoded by an RDS decoder 15 to reproduce the RDS data indicative of type of a broadcasting program content (for instance. PTY : program type ; M/S : music/speech). A ROM 21 of a microcomputer circuit 13 preliminary stores control data prepared correspondingly with the RDS data to be decoded and a CPU 22 outputs the control data and controls equalizer circuits 9L and 9R and tone control circuits 10L and 10R in response to the decoded RDS data so that sound field and tone optimal to the broadcast program content is obtained as an audio output of the receiver.

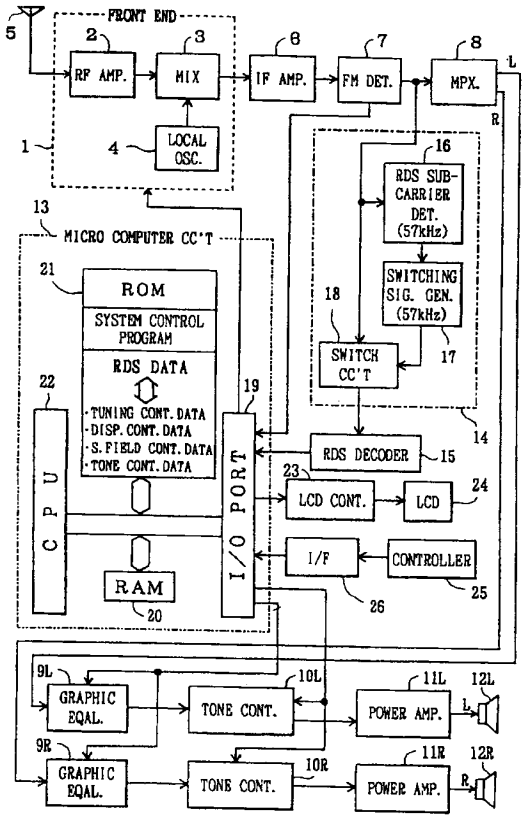

Fig.1

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BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a sound field and tone control device for an FM radio receiver and, particularly, to a device which is suitable for use in an FM radio receiver in which a selection of broadcasting station and display of RDS (radio data system) data are performed by using RDS data multiplexed with an FM signal to provide it with a function of automatically setting an optimum sound field and tone correspondingly to a code contained in the RDS data and indicating a content thereof such as broadcasting programs, etc.

Description of the Related Art:

In a recent FM radio broadcasting, implementation of the RDS system is making a progress, in which an FM stereo signal multiplexed with various digital data is transmitted. Such digital data include an auto tuning data which enable the receiver to select automatically from stations broadcasting an identical program, a specific station which provides the best reception to the receiver, and traffic information identification data, etc. Major specifications of such RDS system have been finalized in the European Broadcasting Union (EBU).

Further, it has been known that such system is already employed not only in Europe but also in the United States, Hong Kong and the Union of South Africa, etc.

The RDS system was developed as a broadcasting system for mainly car radio use. That is, in a case where a car is travelling for a long distance trip while receiving an FM broadcasting, a receiver's tuning frequency set to a certain broadcasting station (first station) needs to be retuned manually to a new station (second station) which is broadcasting the same program as the car goes out of service area of the first station and entering into that of the second station. However, it is possible to avoid such inconveniences by making a car radio having a more sophisticated automatic tuning function by receiving an automatic tuning code included in the RDS data broadcast through a network of FM stations covering areas through which the car travels.

Having such automatic tuning function on receivers is particularly demanded by FM stations whose service area is relatively small. Further, since it is possible to multiplex other information service with the main FM broadcasting for transmission, an FM system multiplexed with additional data is considered to be adopted more widely in the near future.

In view of the purposes mentioned above, EBU adopted and defined the RDS system as to satisfy the following conditions:

(1) With ease of tuning operation of a receiver being a first objective, the function to tune to a best receptive station among receiving stations broadcasting an identical program, is realized.
(2) To have a transmission capacity enough to transmit information related to other programs.
(3) To have an extendability of system for a future expansion of application.
(4) No disturbance from data channels to audio channels.
(5) Reliability against a multipath problem.
(6) Compatibility with a traffic information identifying system which is already in service in some areas.

Designations, contents and functions of major RDS data systems compiled by EBU are exemplified as follows:

* PI (Program identification): Each broadcasting network has own unique code, country code and service area code, etc. Stations having identical PI code belong to the same network and broadcast the same programs.
* PS (Program service name) : Name of broadcasting station composed of 8 characters (ASCII pseudo code).
* PTY (Program type): Code indicating a content of a broadcasting program (news/sports/music, etc.).
* TP (Traffic-program identification) : Identifying code of traffic information agency.
* AF (List of alternative frequency): A list of frequencies of adjacent broadcasting stations within the same network.
* PIN (Program item number) : Program identification code represented by the starting date and time of program. The code corresponds to program reservation and telephone message recording system etc.
* RT (Radio text) : Text data of 64 or 32 letters. Main purpose is to character display on a home receiver.
* ON (Information concerning other networks): Information (PI, PIN, TP, PTY, AF) related to up to 8 networks.
* CT (Clock-time and date): Date and time codes. For- date, the dominical year data, and for time, a time offset data between the station's local time and the universal time, are transmitted.
* EON (Enhanced other networks): To receive a strong station within the network other than the stations (in the AF list) broadcasting a same program.
* M/S (Music/speech): A switch signal for identifying either music signal or speech signal.

When an RDS data is transmitted from a broadcasting station, a DSB (double side band) modulation signal is produced through steps shown in Fig. 4 and

multiplexed with a main FM broadcasting signal. That is, a transmission basic clock A [Fig. 4(A)] of 1.1875 kHz is first encoded with RDS data B [Fig. 4(B)] to produce a differentially encoded RDS data C [Fig. 4(C)], and a bi-phase PSK signal D [Fig. 4(D)] is obtained by bi-phase PSK (phase-shift keying) modulation of the encoded RDS data C using the clock A. Then, the bi-phase PSK signal D is high-pass filtered to obtain a signal E [Fig. 4(E)] and a suppressed carrier modulated signal (DSB modulated signal) F [Fig. 4(F)] is obtained by double sideband modulation of a sub-carrier (57 kHz) with the signal E. Both sidebands of the DSB modulated signal F are multiplexed with the main FM broadcasting signal and transmitted.

Accordingly, as shown in Fig. 5, the resultant RDS signal F [DSB modulated signal] is simply one of modulated signals included (multiplexed) in the FM broadcasting signal in the frequency spectrum thereof, and a degree of modulation of the main carrier of the FM broadcasting with the RDS signal is as low in standard as about 2.7% (± 2 kHz), thus it does not affect the broadcast main FM signal (a composite signal composed of a main channel signal, a sub-channel signal and a pilot signal).

The sub-carrier (57 kHz) of the RDS data is set in phase or quadrature at the third harmonic of the pilot signal (19 kHz).

As mentioned previously, the main purpose of the RDS system is to give an automatic tuning function to the FM radio receivers, and a function of displaying RDS data content (name of the broadcasting station and the program content, etc.) on the receivers is incidentally utilized, but any more positive utilization of the RDS data in the side of FM receivers has been attempted.

On the other hand, there are many FM receivers which have graphic equalizer circuits and tone control circuits to provide a various sound fields and tones. In such FM receivers, it is quite common that such sound field and tone control are performed manually, and once they are adjusted, they are often forgotten and not readjusted. Therefore, under such situation, listening to FM broadcasting with sound field and tone optimum to the broadcast program is very rare.

In a broadcasting of RDS system, such as PTY or M/S included in RDS data have a close relationship with sound field and tone of a reproduced sound and it is possible to perform a discrimination between program content, music and speech by utilizing such data to thereby reproduce the program with sound field and tone optimum to the broadcast content making the FM radio reception more enjoyable.

SUMMARY OF THE INVENTION

Accordingly it is a general object of the present invention is to provide a sound field and tone control device for use in an FM radio receiver, which can automatically and in real-time control sound field and tone of a reproduced sound optimal by utilizing an identification signal which is multiplexed with an FM signal such as RDS and which is indicative of a content of broadcasting program and/or kind of sound.

Another and specific object of the present invention is to provide a sound field and tone control device for use in an FM radio receiver, which comprises signal detection means for detecting identification signals multiplexed with an FM signal, which are indicative of content of a broadcasting program and/or kind of sound, decoding means for decoding the identification signal detected by the signal detection means, memory means for storing sound and tone control data prepared correspondingly to decoded data of the respective identification signals multiplexed with the FM signal and control means for reading the sound field and tone control data stored in the memory means correspondingly to the decoded data therein, on the basis of the decoded data of the identification signals obtained from the decoding means, and controlling a variable sound field and tone circuit of the FM radio receiver by using the control data thus read out.

By utilizing the identification signal indicative of a content of a broadcasting program multiplexed with the FM signal and/or kind of sound, it becomes possible to output a reproduced signal as an audio sound having optimal sound field and tone to the content of a broadcast audio signal and a kind thereof.

The identification signal multiplexed with the FM signal is detected by the signal detection means and decoded by the decoding means. The memory means functions to convert the decoded identification signal into control data for the variable sound field and tone circuit, the control data having a content for realizing an optimal sound field and tone correspondingly with the identification information.

Therefore, by detecting the identification signal from the FM signal continuously or at a constant interval, reading the control data from the memory means by means of the control means and controlling the variable sound field and tone circuit accordingly, it is possible to maintain the reproduced sound at optimal sound field and tone automatically and in real-time.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a system circuit diagram of an FM receiver (stereo car-radio receiver) responsive to an RDS broadcasting system;

Fig. 2 is a flowchart showing operating procedures of RDS data display and automatic tuning functions;

Fig. 3 is a flowchart showing operating procedures of sound field and tone control settings;

Fig. 4 is a signal timing chart showing a modula-

tion scheme of the RDS data; and

Fig. 5 is a graph showing a frequency spectrum of a broadcast FM signal in the RDS broadcasting system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of a sound field and tone control device for use in an FM radio receiver according to the present invention, will be described with reference to Figs. 1 to 3.

Fig. 1 shows a system circuit diagram of an FM receiver (stereo car-radio receiver) responsive to an RDS broadcasting system.

In Fig. 1, the FM receiver includes a front end 1 composed of a radio frequency amplifier (RF AMP) 2, a mixer (MIX) 3 and a local oscillator (LOCAL OSC) 4. The front end 1 tunes to an FM broadcasting signal received at an antenna 5, amplifies it and converts it into an intermediate frequency signal (10.7 MHz).

The intermediate frequency signal is amplified by an intermediate frequency amplifier (1F AMP) 6 and then detected by an FM detector (FM DET) 7, resulting in a low frequency signal. The low frequency signal is a composite signal including a main channel signal (L+R; up to 15 kHz or lower), a sub-channel signal (L-R; DSB of 23 - 38 kHz and 38 - 53 kHz) and a pilot signal (19 kHz). Further included is a stereo demodulator (MPX) 8 which demodulates an L signal and an R signal by using the pilot signal since the receiver is an FM stereo receiver.

The demodulated L and R signals are supplied to a reproduction circuit having an L channel and an R channel. The L channel includes a graphic equalizer circuit 9L for adding reverberation by causing a signal delay, a tone control circuit 10L, a power amplifier 11L and a loud speaker 12L and the R channel includes, correspondingly to the L channel, a graphic equalizer circuit 9R, a tone control circuit 10R, a power amplifier 11R and a loud speaker 12R. The equalizer circuits 9L and 9R and the tone control circuits 10L and 10R are controlled by a microcomputer circuit 13.

In order to make the FM radio receiver compatible with the RDS broadcasting system, it includes an RDS signal detection section 14 and an RDS decoder 15. The RDS signal detection section 14 includes an RDS sub-carrier detection circuit 16, a switching signal generator circuit 17 and a switching circuit 18. The sub-carrier detection circuit 16 detects a sub-carrier (57 kHz) upon which the switching signal generator circuit 17 generates a switching signal having the same frequency as that of the sub-carrier. The switching circuit 18 switches the output of the FM detector 7 with a timing of the switching signal to detect the RDS signal F [DSB modulated RDS signal] shown in Fig. 4(F). The RDS decoder 15 demodulates the signal through a process in a reversed order of the modulation scheme shown in Fig. 4 and outputs the RDS data.

On the other hand, the microcomputer circuit 13 includes an I/O port (including an A/D converter and a D/A converter) 19, a RAM 20, a ROM 21 and a CPU 22. The ROM 21 stores a system control program for controlling the receiver as a whole and stores, in a table format, tuning and display data and sound field and tone control data prepared correspondingly to various RDS data. This embodiment is featured by the fact that the ROM 21 stores the sound field and tone control data.

An LCD control section 23 functions to display the various RDS data obtained by the microcomputer circuit 13 on an LCD 24 and a controller 25 functions to output manual control data to the microcomputer circuit 13 through an interface I/F 26.

A control operation of the FM radio receiver to be performed by using the RDS data in this embodiment will be described with reference to flowcharts shown in Figs. 2 and 3.

Fig. 2 is a flowchart showing operating procedures of RDS data display and automatic tuning functions.

Although, in this receiver, station tuning and sound field and tone control settings can be selectively performed through the controller 25 in an automatic control mode or a manual control mode, it is assumed in this embodiment that the automatic control mode is selected.

Further assuming that a broadcasting signal of RDS system is being received from a certain broadcasting station, the RDS signal detection section 14 detects the RDS signal and the microcomputer circuit 13 acquires the RDS data from the RDS decoder 15 every constant time period ΔT (for example, every 0.5 sec.) and stores them in the RAM 20 (steps S1, S2). In this case, the CPU 22 renews the RDS data previously stored in the RAM 20 every time new RDS data is acquired through the I/0 port 19.

Further, the CPU 22 outputs display data to the LCD control section 23 through the I/0 port 19 by using the display control data corresponding to the RDS data to renew a display content on the LCD 24 (step S3).

That is, the network designation corresponding to PI of the RDS data, the name of the broadcasting station corresponding to PS thereof, the kind of program ("news", "sports", "music", etc.) identified by PTY thereof, the frequency of receiving station obtained by PS and AF thereof and the date and time using CT, etc., are displayed on the LCD 24.

On the other hand, it is possible to detect field strength of received signal by the FM detector 7. However, since the radio receiver is a car radio thus moving in this embodiment, the field strength reduces as a distance from the broadcasting station increases.

The CPU 22 checks whether the field strength

becoming a predetermined level or lower than that (step S4) and retuning of the front end 1 is needed, and if it is "YES" it executes retuning of the front end 1 by using tuning control data corresponding to PI, AF and EON of the RDS data stored in the RAM 20 (step S5).

That is, the tuning frequency of the front end is shifted sequentially through those of broadcasting stations which are in the same network as that of the previously tuned station and are broadcasting programs of the same content and the tuning frequency of the front end is fixed to one of them having a highest field strength.

Then, since the above mentioned procedures are executed every ΔT time period (steps S6 to S1), renewed RDS data are displayed on the LCD 24 sequentially and thus it is possible to listen always the broadcasting program under the best receiving condition.

As described in the above, the latest RDS data is stored in the RAM 20 of the microcomputer circuit 13 every ΔT time period according to the procedures shown in Fig. 2.

Therefore, by confirming PTY and M/S of the latest RDS data, it is possible to identify the program content of currently receiving broadcasting and further possible to know whether the receiving signal at every moment is a musical signal or a speech signal.

In the FM radio receiver of this embodiment, sound field and tone control setting procedures shown in Fig. 3 are executed by the microcomputer circuit 13 in parallel to the above mentioned operating procedures.

That is, the RDS data in the RAM 20 is sequentially rewritten in the above mentioned procedures. The CPU 22 confirms PTY and M/S of the RDS data every time it is rewritten, and reads out the preliminary stored sound field and tone control data corresponding to the confirmed data, and controls sound field and tone condition optimal to the program content, the music or the speech by controlling the graphic equalizer circuits 9L and 9R and the tone control circuits 10L and 10R (steps S11, S12).

In detail, when the program content confirmed from PTY is a news program, sound field is adjusted to a state close to a monaural output and significant.audio signal components of the voice of announcer or newscaster are enhanced in frequency spectrum to make the voice more legible. When the program content is music or sport, sound field and tone with vivid presence are produced by setting a full frequency range of the reproduced signal in stereo and/or by performing sound field processing for adding reverberation effect.

Further, it is frequent that music and speech are alternatively included in a program. In such a case, a switching from music to speech or vice versa can be confirmed from M/S of the RDS data. Therefore, by performing a similar sound field and tone control to that mentioned above correspondingly with every such switching, the sound field and tone settings can be changed accordingly to optimize the situations.

As a result, it is possible to provide the listener of this FM radio receiver, with an automatic tuning and an information display functions by means of the RDS data as well as an optimal sound field and tone produced from the left and right loud speakers 12L and 12R, that are automatically controlled in real time without any manual operation of the controller 25 which is indispensable in the conventional system where re-setting sound field and tone is often disregarded but left as is.

According to the sound field and tone control device of the FM radio receiver, which is constituted as mentioned previously, there are provided advantages over the conventional system. For example, when an FM signal is multiplexed with identification signals indicative of a broadcasting program content and/or kind of sound as in the RDS system broadcasting, it is possible to give an additional commercial value to the FM radio receiver that a FM broadcasting can be always listened comfortably by reproducing the FM signal with sound field and tone optimal to the program content and nature of the sound on the basis of data obtained from these identification signals without necessity of cumbersome manual controlling.

Claims

1. A sound field and tone control device for an FM radio receiver comprising:

   signal detection means for detecting identification signals multiplexed with an FM signal, said identification signals being indicative of type of a broadcasting program content;

   decoding means for decoding said identification signals detected by said signal detection means;

   memory means for preliminary storing sound field and tone control data prepared correspondingly with said identification signals to be decoded by said decoding means; and

   control means for reading out the sound field and tone control data preliminary stored in said memory means, in response to said identification signals decoded by said decoding means, and for controlling a variable sound field and tone means of the FM radio receiver by using the sound field and tone control data thus read out.

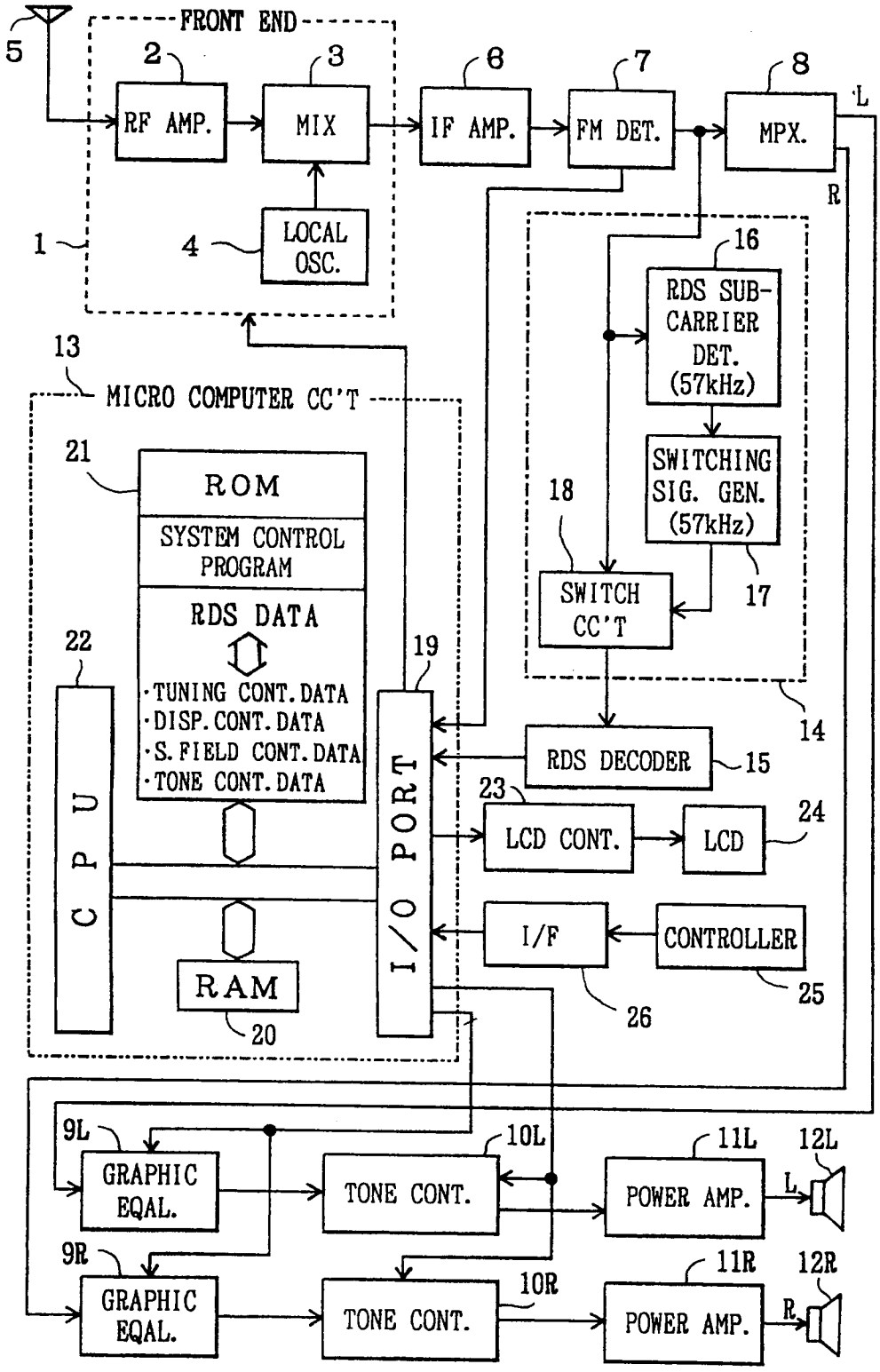

Fig.1

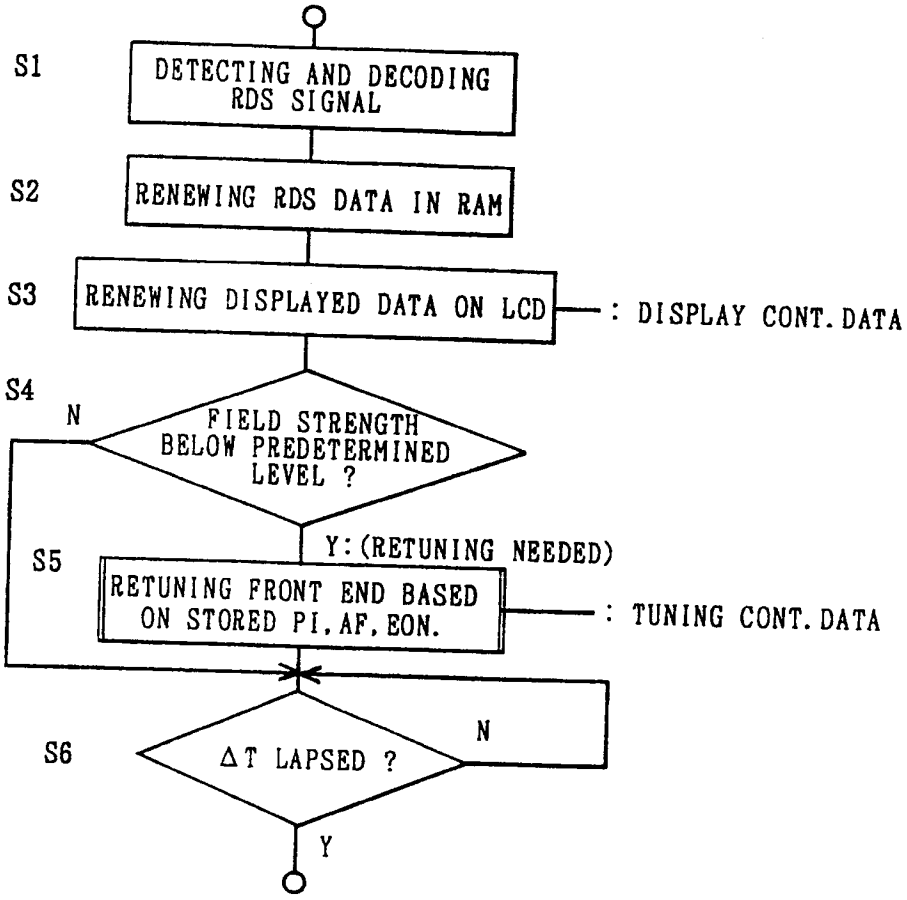

Fig.2

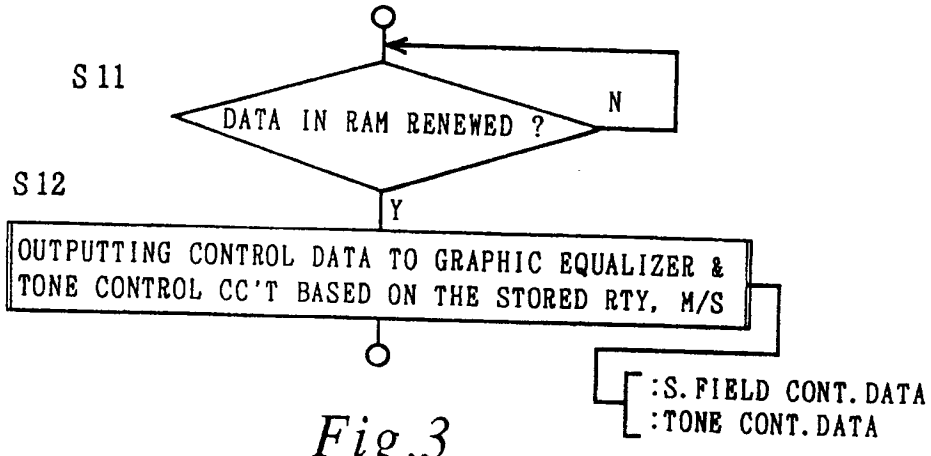

Fig.3

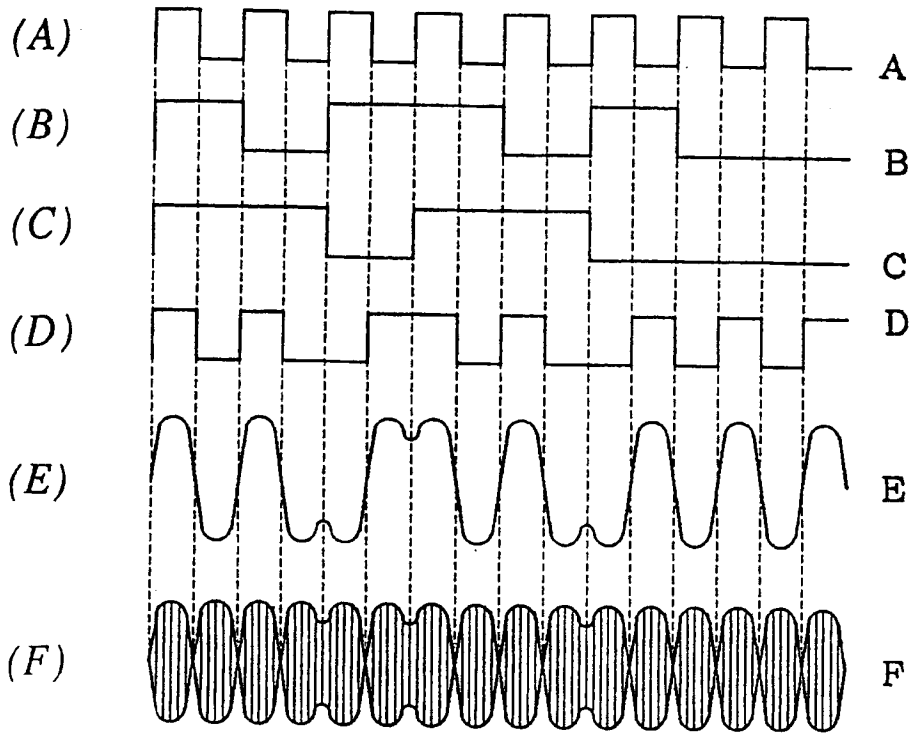

Fig.4

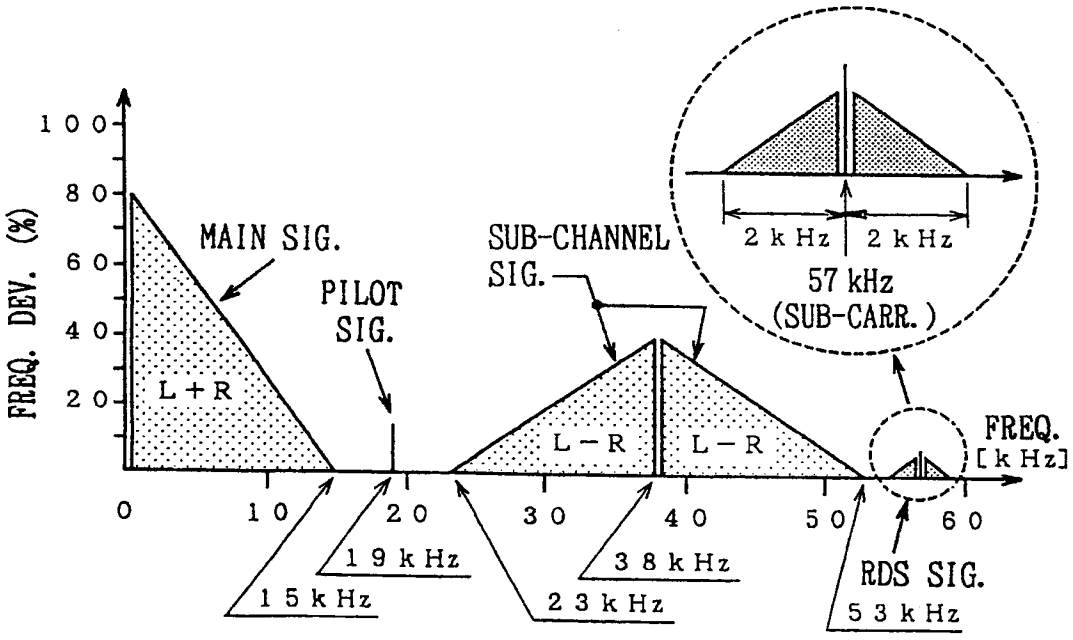

Fig.5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 2227

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	EP-A-0 503 154 (PIONEER ELECTRONIC CORPORATION) * column 1, line 1 - column 3, line 56 * * column 5, line 42 - line 57; claims 1,3-6; figure 3 *	1	H04H1/00
X	GB-A-2 215 927 (BRITISH BROADCASTING CORPORATION) * page 1, line 1 - page 2, line 17; claim 1 *	1	
P,X	EP-A-0 558 918 (GRUNDIG E.M.V.) * column 1, line 1 - column 3, line 38; claims 1,3; figure 1 *	1	
X	PATENT ABSTRACTS OF JAPAN vol. 15, no. 299 (E-1095) 30 July 1991 & JP-A-03 106 129 (TOMOHIRO MAKOTO) 2 May 1991 * abstract *	1	
X	PATENT ABSTRACTS OF JAPAN vol. 13, no. 272 (E-777) 22 June 1989 & JP-A-01 062 922 (SASAKI MITSURU) 9 March 1989 * abstract *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.5) H04H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 June 1994	De Haan, A.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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